DOCUMENT RESUME

ED 093 721 SE 018 103

AUTHOR	Waller, T. Gary; Wright, Robert H.
TITLE	The Effect of Training on Accuracy of Angle Estimation.
INSTITUTION	George Washington Univ., Alexandria, Va. Human Resources Research Office.
SPONS AGENCY	Office of the Chief of Research and Development (Army), Washington, D.C.
REPORT NO	TR-65-8
PUB DATE	Aug 65
NOTE	34p.
EDRS PRICE	MF-$0.75 HC-$1.85 PLUS POSTAGE
DESCRIPTORS	Geometric Concepts; Instruction; *Map Skills; *Mathematical Applications; Measurement; *Navigation; *Research
IDENTIFIERS	*Estimation

ABSTRACT

This report describes a study to determine the effect of training on accuracy in estimating angles. The study was part of a research program directed toward improving navigation techniques for low-level flight in Army aircraft and was made to assess the feasibility of visually estimating angles on a map in order to determine angles of drift. Eighteen subjects were randomly divided into a control group and two training groups. One group was trained using angles drawn on plain white cards and the other group used angles drawn on both cards and tactical maps. The groups estimated the size of angles ranging from 1 degree to 18 degrees. After training, it was found that the test performance of the two training groups on map items was significantly superior to test performance of the control group; on card items there were no significant differences between the two training groups and the control group. There were no significant differences between the two training groups on either card items or map items. The authors conclude that visual estimation of angles on maps appears to be a feasible technique for determining angles of drift. (DT)

ED 093721

Technical Report 65-8

BEST COPY AVAILABLE

The Effect of Training on Accuracy of Angle Estimation

by

T. Gary Waller and Robert H. Wright

HumRRO Division No. 6 (Aviation)

AD_____

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION
THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY.

August 1965

Prepared for:

Office, Chief of
Research and Development,
The Department of the Army

Contract DA 44-188-ARO-2

HumRRO

The George Washington University
HUMAN RESOURCES RESEARCH OFFICE
operating under contract with
THE DEPARTMENT OF THE ARMY

SE 018 103

ED 093721

The Effect of Training on Accuracy of Angle Estimation

by

T. Gary Waller and Robert H. Wright

Prepared for:

Office, Chief of Research and Development,
The Department of the Army
Contract DA 44-188-ARO-2 (DA Proj 2J024701A712 01)

HumRRO Division No. 6 (Aviation)
Fort Rucker, Alabama
The George Washington University
HUMAN RESOURCES RESEARCH OFFICE
operating under contract with
THE DEPARTMENT OF THE ARMY

August 1965

Technical Report 65-8
Task LOWENTRY
Subtask I

The Human Resources Research Office is a nongovernmental agency of The George Washington University, operating under contract with the Department of the Army (DA 44-188-ARO-2). HumRRO's mission, outlined in AR 70-8, is to conduct research in the fields of training, motivation, and leadership.

The findings in this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

Published
August 1965
by
The George Washington University
HUMAN RESOURCES RESEARCH OFFICE
300 North Washington Street
Alexandria, Virginia 22314

Distributed under the authority of the
Chief of Research and Development
Department of the Army
Washington, D.C. 20310

FOREWORD

Task LOWENTRY has as its overall objectives the improvement of navigation techniques for low-level flight in Army aircraft and the development of training methods to teach these techniques to aviation personnel. Activities directed toward these objectives were begun by the Human Resources Research Office in 1961 at Fort Rucker, Alabama, under the sponsorship of the U.S. Continental Army Command.

In Subtask I, An Analysis of the Training Requirements for Low Altitude Navigation, factors influencing low altitude navigation have been defined, promising approaches explored, and development of training begun. In Subtask II, an experimental source text on Army aircraft navigation is being prepared.

As one of several Subtask I studies being conducted to determine the feasibility of certain navigation techniques at low altitude, the work reported here was performed to investigate the effect of training on the accuracy of angle estimation. Additional reports, in preparation, will deal with other elements of the problem of simplifying operational tasks of Army pilots, such as the smallest scale map that an Army aviator can use effectively, and the influence of map scale, subject task, and coordinate scale usage on map locational accuracy. Already published is a Consulting Report, *Pictorial Navigation Displays and Low Altitude Navigation*, by Robert H. Wright and Thomas G. Waller, April 1964. A general survey report on factors influencing Army low altitude navigation is also being prepared under LOWENTRY I.

Task LOWENTRY, Methods for Improving Navigation Training for Low-Level Flight, is being conducted by the Human Resources Research Office under Army Contract DA 44-188-ARO-2 and Army Project 2J024701A712 01, Training, Motivation, Leadership Research.

The LOWENTRY research is being performed at HumRRO Division No. 6 (Aviation), at Fort Rucker, Alabama, with Dr. Robert H. Wright as the Task Leader. The present Director of Research of the Division is Dr. Wallace W. Prophet; Dr. J. Daniel Lyons was Director of Research at the time the research was begun.

Military support for the study was provided by the U.S. Army Aviation Human Research Unit. Task LOWENTRY was begun when Lt. Col. Arne H. Eliasson was Unit Chief and continued while Maj. Donald J. Haid was Chief. Lt. Col. Berkeley D. More is the present Unit Chief.

MEREDITH P. CRAWFORD
Director
Human Resources Research Office

SUMMARY AND CONCLUSIONS

PROBLEM

In the navigation of aircraft, it is sometimes necessary for the pilot to determine the heading change or correction angle required to get back on course. This angle may be measured or estimated. Results of previous research indicate that measurement and certain types of estimation are not feasible during flight at low altitudes.

The present study was conducted to determine the effect of training on accuracy of angle estimation and the feasibility of using direct perceptual estimation to determine angles of drift.

RESEARCH PROCEDURE

Eighteen subjects were randomly divided into three groups--two training groups and one control group. One training group was trained in angle estimation using angles drawn on plain white cards; the other training group used angles drawn both on cards and on tactical maps in their training.

The two training groups were tested on angle estimation performance, were administered different training programs of approximately one-half hour, and then were tested again. One week later the training groups were given a third test; they were then provided with a job aid and tested a fourth time. The procedure for the control group was the same as for the training groups except that the control group did not receive any training.

RESULTS

The results indicated that:

(1) Before training, subjects in the training groups estimated angles of 1° to 18° on maps with a mean absolute error of 2.57° and a mean algebraic error of -0.20°.

(2) Training produced significant increases in accuracy of angle estimation for both training groups, with mean absolute error on maps after training found to be 1.34°. Mean algebraic error changed significantly to +0.43°.

(3) After training, the card items continued to be underestimated, whereas the map items tended to be overestimated.

(4) The improvement produced by training did not significantly decline after a one-week interval.

(5) The different training programs did not produce significantly different performance between the two training groups.

(6) A job aid consisting of reference angles of 5°, 10°, and 15° did not significantly improve performance on maps for either the training groups or the control group. For the training groups,

on the card items the job aid shifted the error from underestimation to slight overestimation of angle size.

CONCLUSIONS

It is concluded that direct perceptual estimation on maps appears to be feasible as a technique for determining angles of drift, and this ability can be improved by a small amount of training.

CONTENTS

	Page
INTRODUCTION	3
METHOD	4
Design and Procedure	4
Subjects	4
Training Materials	6
The Job Aid	6
RESULTS	9
DISCUSSION	17
Appendix: Instructions for the Three Groups.	21
Introduction to the Experiment for All Three Groups.	21
Instructions for the Study Session for the Training Group	22
Instructions for the Control Group	23
Instructions for T_3 for All Three Groups	23
Instructions for T_4 for All Three Groups	24

Figure

1	An Example of Each Type of Test Item.	5
2	An Example of a Page of the Training Text	7
3	The Angle Estimation Job Aid (Actual Size).	8
4	Mean Absolute Error Before and After Training	10
5	Mean Absolute Error on Map Items.	11
6	Mean Absolute Error on Card Items	11
7	Error on Map Items as a Percentage of Test 1.	13
8	Error on Card Items as a Percentage of Test 1	13
9	Mean Algebraic Error on Map Items	15
10	Mean Algebraic Error on Card Items	15
11	Mean Algebraic Error After Training for Map and Card Items by Angle Size	16

Table

1	Mean Absolute Error and Error Ratio by Angle Size	9
2	Mean Absolute Error on Map and Card Items	12
3	Probability Levels for Differences Between Pairs of Tests.	14
4	Probability Levels for Differences Between Training and Control Groups for Performances on Tests 2, 3, and 4 as Compared With Test 1	17
5	Mean Algebraic Error on Map and Card Items.	17

The Effect of Training on Accuracy of Angle Estimation

BEST COPY AVAILABLE

INTRODUCTION

The objectives of the research being conducted under Task LOWENTRY at HumRRO Division No. 6 (Aviation), Fort Rucker, Alabama,[1] are to develop improved navigation techniques for low altitude flight and to develop training methods to teach necessary skills to aviator personnel.

In tactical environments Army aviators conduct aerial flights with obstacle clearances of 1 to 500 feet, at speeds of 35 to 250 miles per hour. Such low altitude flights subject the aviator to much higher task loadings than do flights at higher altitudes, and conventional nonradio navigation techniques are found to be inadequate at these levels. The pilot's time and attention must be divided between the navigation tasks and all the other tasks associated with controlling the aircraft, avoiding obstacles, and successfully completing specific missions. One approach to providing adequate low altitude navigation techniques and training is to reduce or simplify the tasks involved.

One of the pilot's navigation tasks is the determination of heading changes for correcting off-course situations. When a pilot finds himself off his planned route, he must determine a correction angle. This angle can be determined by measuring it on a map with a protractor, by computing it with a trigonometric relationship called the "rule of 60," or by visually estimating the size of the angle on the map. At low altitudes the pilot's task loading does not permit him sufficient time to measure an angle with a protractor, and available data[2] indicate that errors made using the "rule of 60" would be unacceptably high. Consequently, the pilot's best recourse may be to estimate a correction angle by visual reference to his map.

The experiment reported here was designed to investigate:

(1) The accuracy with which untrained subjects can estimate angles.

(2) The effect of training on the accuracy of angle estimation.

---

[1]The term "U.S. Army Aviation Human Research Unit," which was used prior to 1 January 1965 to include both HumRRO staff and the Unit supporting military staff provided by the U.S. Continental Army Command, is now used, more specifically, to denote the military contingent of the Fort Rucker research group.

[2]United States Army Aviation Board, *Report of Test. Project No. AVN 4860.1/61 Phase III of Man Machine Environment Compatibility Studies and Test in Support of Surveillance Aircraft Development*, Fort Rucker, Alabama, 28 May 1962 (FOR OFFICIAL USE ONLY).

(3) The stability of training effects over a time period of one week.

(4) The relative effectiveness of two types of training materials, which differ in terms of their similarity to the criterion task.

(5) The effect of a simple job aid on the accuracy of angle estimation.

METHOD

Design and Procedure

Three groups were utilized in the experiment; two were training groups (A and B) and the third was a control group (C). The two training groups were tested on angle estimation performance, were administered a training program of approximately one-half hour, and then were tested again. The procedure for the control group was the same except that no training was administered.

The instructions given in the various testing and training situations are contained in the Appendix.

Subjects

Each of the three groups was composed of six subjects--three males and three females. The subjects were randomly assigned to the three groups, with the restriction that males and females be evenly divided among the groups.

All 18 subjects were personnel of the U.S. Army Aviation Human Research Unit. Seven of the nine males were enlisted men in the Army, one was a retired lieutenant colonel, and one was a civilian research assistant. Five of the nine females were secretaries, one was an administrative assistant, one was a librarian, and two were technical assistants.

Three test forms were used in a counterbalanced arrangement for the first three tests. For each subject, the form used for the first test was used again for the fourth test.

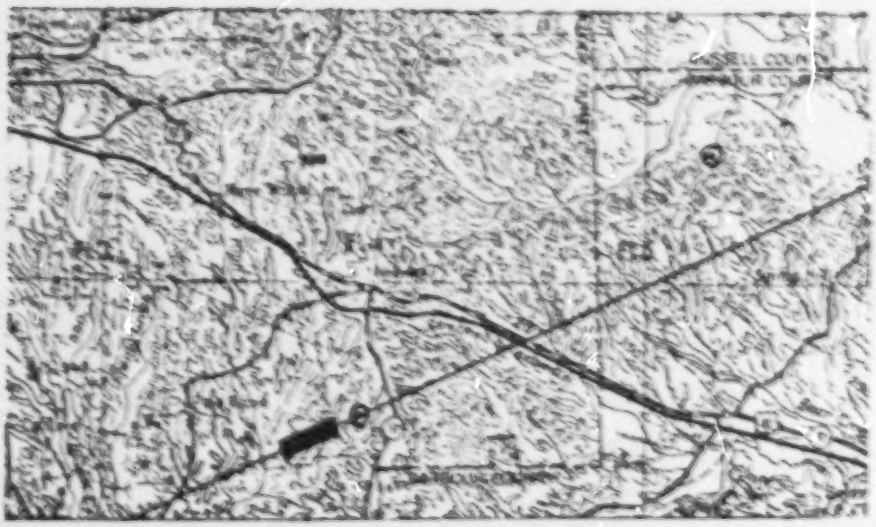
Each test form contained 72 items bound in a loose-leaf notebook, one item per page. The 72 items were angles of 1° through 18° presented four times each. Each angle size was presented twice on plain white cards and twice on map sections of scale 1:250,000. The cards and the map sections were 5 inches wide and 8 inches long. An example of each type of item is shown in Figure 1.

On card items, the angles were drawn with arms 4 inches long. On the map items, a straight line representing a navigation course line was drawn across each map section. The course line defined one side of the angle; the other side was indicated by a dot on the line and another dot off the line. A circle three-sixteenths of an inch in diameter was drawn around each dot. The distance between the dots was 4 inches.

On 18 of the 36 map angles, the off-the-line dot was clockwise from the course line and the origin dot, and on the other 18 map items it was counterclockwise. The position--clockwise or

AN EXAMPLE OF EACH TYPE OF TEST ITEM

Card Item



Map Item

Figure 1

counterclockwise--was randomly determined, with the restriction that half of the dots fall into each category.

Orientations of the angles on the cards and maps were balanced over 36 compass points spaced at 10° increments beginning at zero. Each angle size was presented twice on cards and twice on maps; the two presentations of each type of item were at least 100° different in orientation.

The order in which the 72 items were presented in a test form was randomly determined, with the restriction that adjacent items could not be the same angle size.

Training Materials

A different training book was developed for each training group. For the first group (A), all study items were drawn on cards. For the second group (B), half of the items were drawn on cards and the other half on maps.

Each training book began with instructions for the study session. Reference angles of 5°, 10°, and 15° were then pictured; the subject was allowed to study these pictures as long as he wished. Then 54 training items were presented, with each angle from 1° through 18° being shown three times.

The 54 training items were drawn exactly like the test items. Orientations were balanced across the 36 compass positions, with the restriction that two of the items for each angle size had to be at least 100° different in orientation. Order of presentation was randomized, with the restriction that no adjacent items could be the same angle size. For Group B, the card-map training group, the position of the dot on the map items was randomly determined.

The correct size of each angle was written on a tab that was placed face down near the bottom of the page. An example of a card training item is shown in Figure 2. A similar format was used for map training items. The subject wrote his estimate of the angle size on the answer sheet, then raised the tab and looked at the correct figure. If his estimate was correct, he proceeded to the next item; if incorrect, he drew a line through his response and wrote the correct answer beside it. Each subject was permitted to work at his own rate.

The Job Aid

A job aid, which is shown in Figure 3, was provided for use by all subjects on the fourth test. The job aid was a card 5 inches wide and 8 inches long on which reference angles of 5°, 10°, and 15° were drawn. The three angles had arms 2 1/2 inches long drawn as lines radiating from the same origin. The left arm was oriented at 360° and was common to all three angles.

For reference during the test, the card was placed in an upright position on a desk at a distance of approximately 28 inches from the subject's eyes.

AN EXAMPLE OF A PAGE OF THE TRAINING TEXT

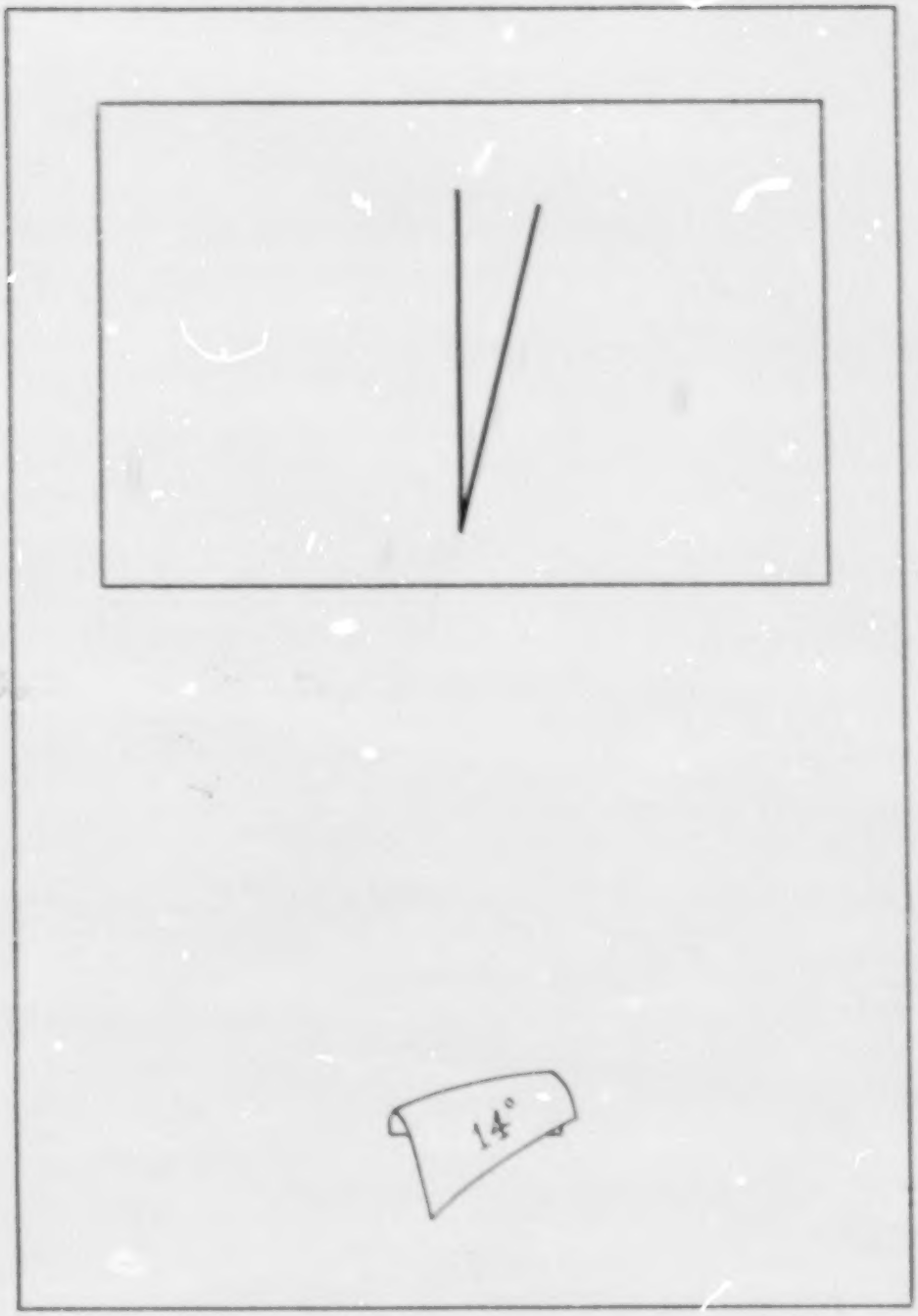


Figure 2

THE ANGLE ESTIMATION JOB AID (ACTUAL SIZE)

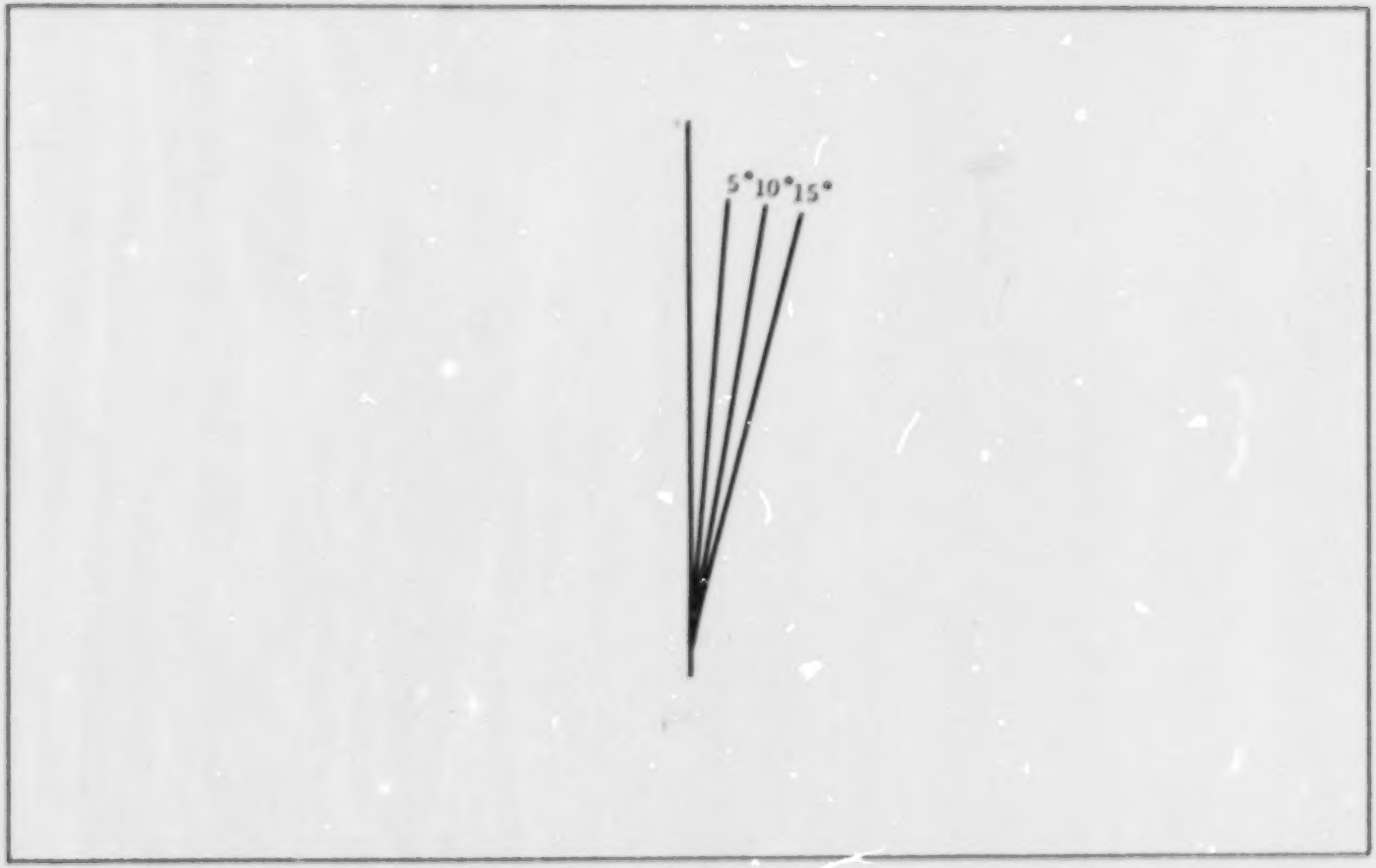


Figure 3

RESULTS

The dependent variable measured was angle estimation error in degrees. *F max* tests[1] indicated that the variances were extremely nonhomogeneous. Therefore, no attempt was made to subject the data to parametric analyses.

Mean absolute error before and after training is shown for each angle size in Figure 4. The "before training" curve includes data for the two training groups on Test 1; the "after training" curve includes data for the same two groups on Test 2. Error increased as angle size increased up to 15°, but decreased slightly on the larger angle sizes. The somewhat greater accuracy in estimating the larger angles may be attributed to the fact that subjects were told in the instructions that no angle would be larger than 18°.

Performance with and without training is reported in Table 1. It shows mean absolute error on Tests 1 and 2 and the ratio of error on Test 2 to that on Test 1 $\left(\frac{\text{Test 2 error}}{\text{Test 1 error}}\right)$, for training and control groups, and for three levels of angle size. At all three levels, the ratio of error was lower for the training groups than for the control group. The ratio of error $\left(\frac{\text{Test 2 error}}{\text{Test 1 error}}\right)$ for all angle sizes combined was .52 for the training groups versus .83 for the control group.

The training groups showed greatest improvement in estimating the small angle sizes; the error ratio increased as angle size increased. For the control group, the error ratio decreased as angle size increased.

Mean absolute error for Groups A, B, and C--the card, card-map, and control groups respectively--is shown in Figure 5 (map items) and Figure 6 (card items). The same data and that for Groups A and B combined are shown in Table 2.

Table 1

MEAN ABSOLUTE ERROR AND ERROR RATIO BY ANGLE SIZE

Angle Size (degrees)	Training Groups			Control Group		
	Mean Error (degrees)		Error Ratio	Mean Error (degrees)		Error Ratio
	T1	T2	T2/T1	T1	T2	T2/T1
1 - 5	1.21	.53	.44	.97	.94	.97
6 - 10	2.64	1.30	.49	2.16	1.79	.83
11 - 15	2.98	1.72	.58	3.28	2.42	.74
All Angles	2.33	1.20	.52	2.16	1.81	.83

[1] B.J. Winer, *Statistical Principles in Experimental Design*, McGraw-Hill Book Company, Inc., New York, 1962.

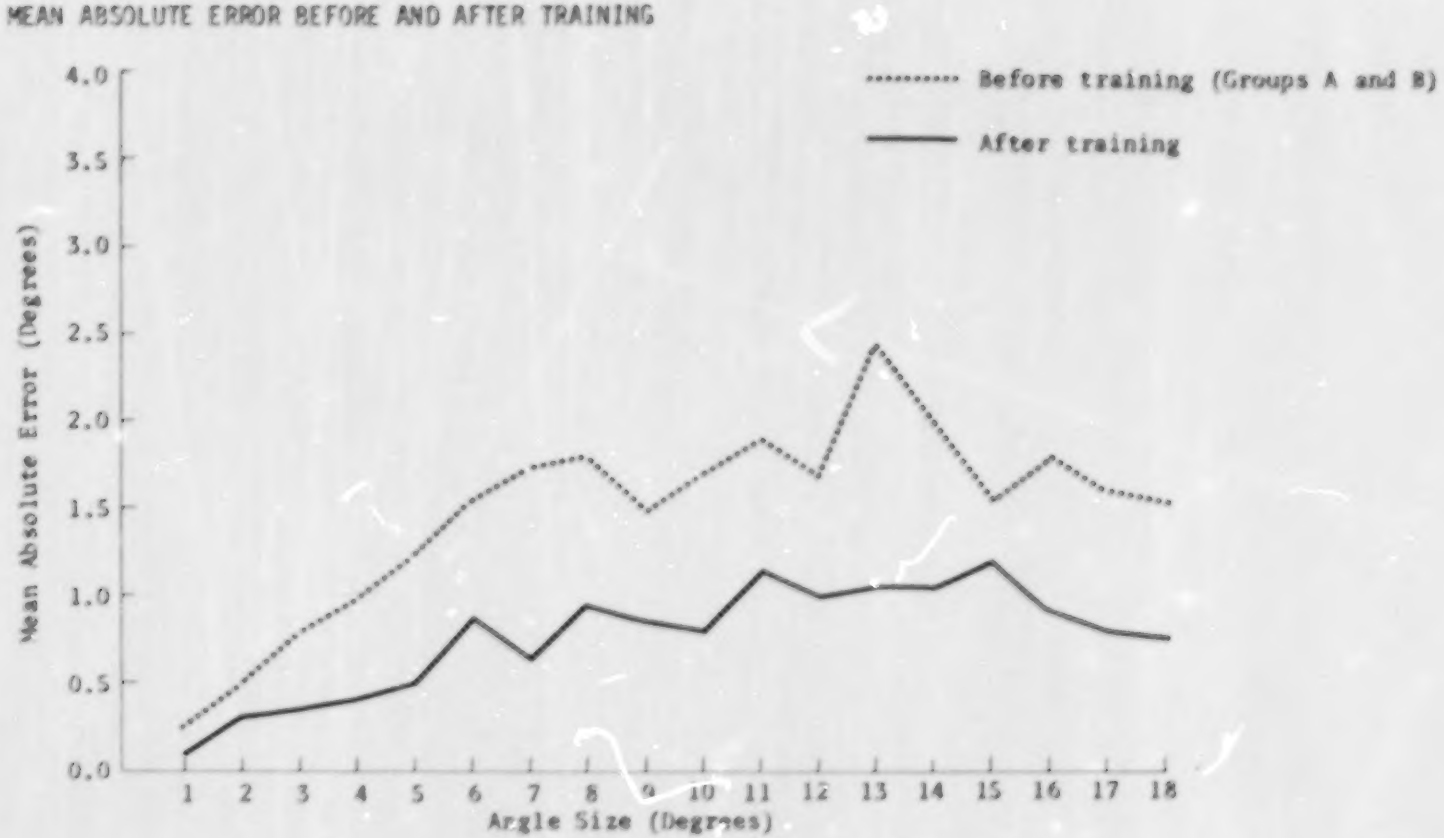

MEAN ABSOLUTE ERROR BEFORE AND AFTER TRAINING
Before training (Groups A and B)
After training
Mean Absolute Error (Degrees)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Angle Size (Degrees)

Figure 4

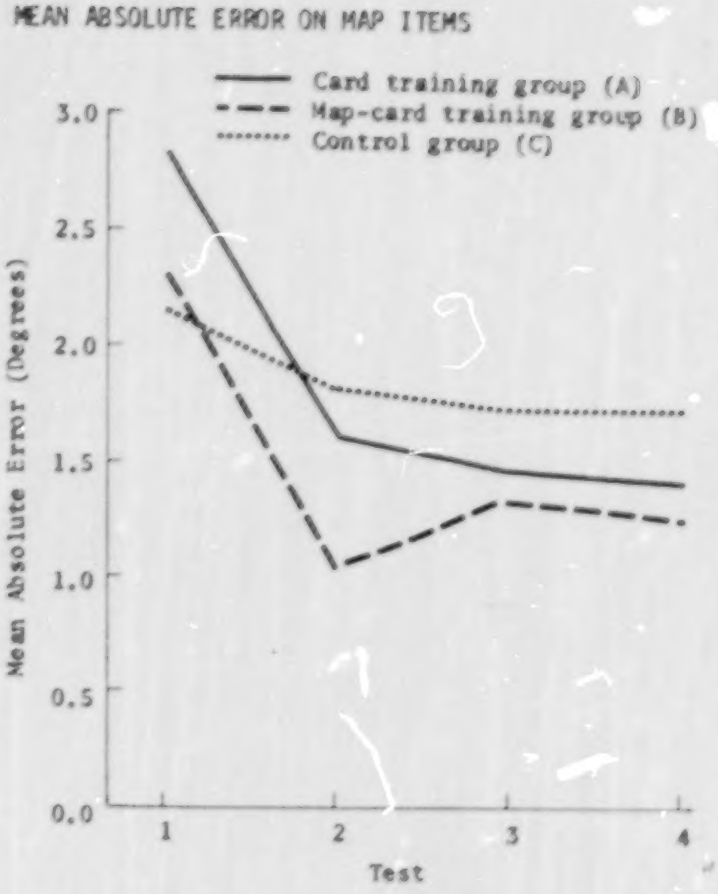


Figure 5

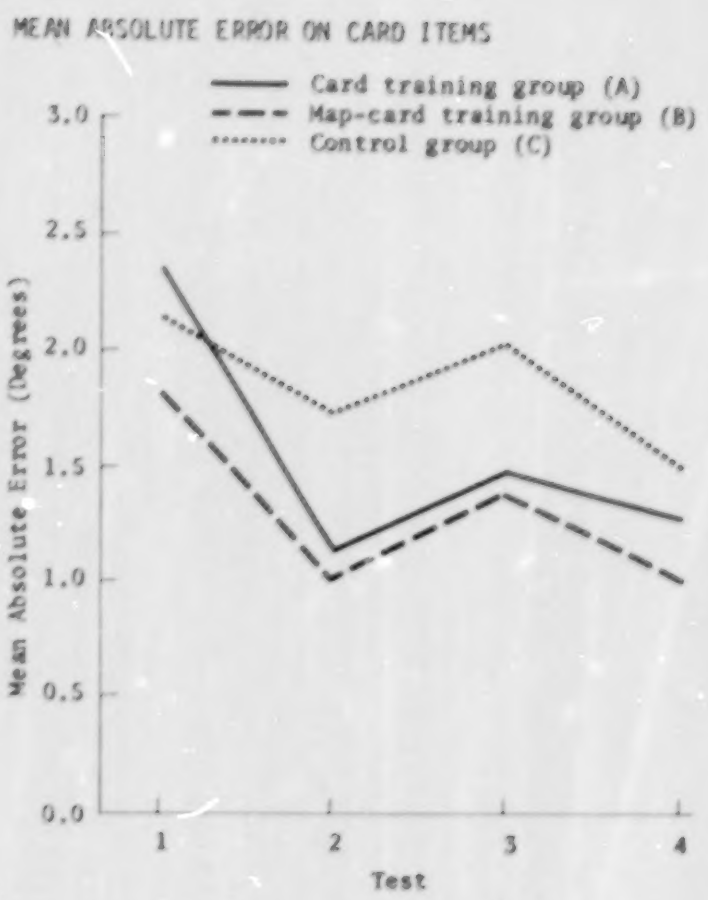


Figure 6

Table 2

MEAN ABSOLUTE ERROR ON MAP AND CARD ITEMS

Group	Map Items (mean error in degrees)				Card Items (mean error in degrees)			
	T1	T2	T3	T4	T1	T2	T3	T4
A	2.82	1.61	1.48	1.41	2.38	1.11	1.48	1.26
B	2.31	1.06	1.34	1.27	1.80	1.02	1.36	1.02
A & B	2.57	1.34	1.41	1.34	2.09	1.07	1.42	1.14
C	2.17	1.84	1.76	1.75	2.16	1.77	2.03	1.49

To test for the significance of differences among the four tests, nonparametric Friedman analyses of variance[1] were computed on map items and on card items. The differences were not statistically significant for the control group on either map or card items, though the difference for map items approached the .05 level of significance.

In general, for map items error decreased from Test 1 to Test 2, from Test 2 to Test 3, and from Test 3 to Test 4, although only the decreases from Test 1 to Test 2 were statistically significant at less than the .05 level. The only exception to this decrease in error between tests was from Test 2 to Test 3 for Group B. For card items, error decreased from Test 1 to Test 2, increased from Test 2 to Test 3, and decreased from Test 3 to Test 4.

The immediate effects of the training programs can be seen in Table 2 in the mean error of 2.57° on Test 1 and of 1.34° on Test 2 for the combined training groups. This is a 48% reduction in error.

Nonparametric sign tests[2] were computed for the differences between pairs of tests for each of the three groups separately and for the two training groups combined. On map items, error on Tests 2, 3, and 4 was significantly lower than error on Test 1, in most cases. Test 2 did not differ significantly from Test 3 or 4; Test 3 did not differ significantly from Test 4. Specific probabilities for the differences between pairs of tests on both map items and card items are shown in Table 3.

To facilitate comparison of the three groups on Tests 2, 3, and 4, mean errors on Test 2, Test 3, and Test 4 were converted to the ratio of mean error on Test 1. The error ratio on map items is shown in Figure 7; the error ratio on card items is shown in Figure 8. The error ratio for the training groups was lower than the error ratio for the control group on all tests for both card items and map items.

---

[1] S. Siegel, *Nonparametric Statistics for the Behavioral Sciences*, McGraw-Hill Book Company, Inc., New York, 1956.

[2] *Op. cit.*

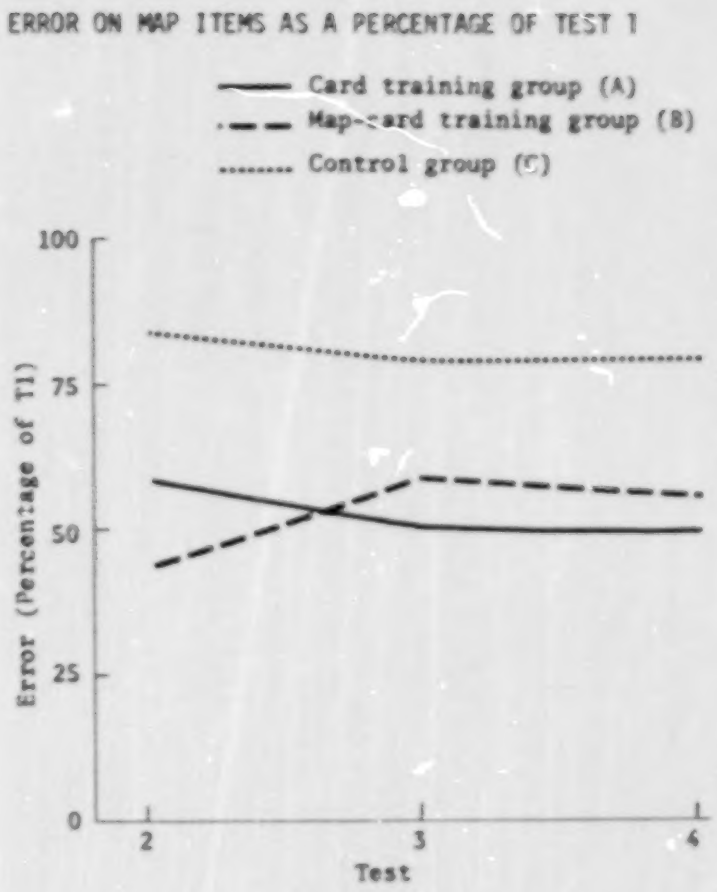


Figure 7

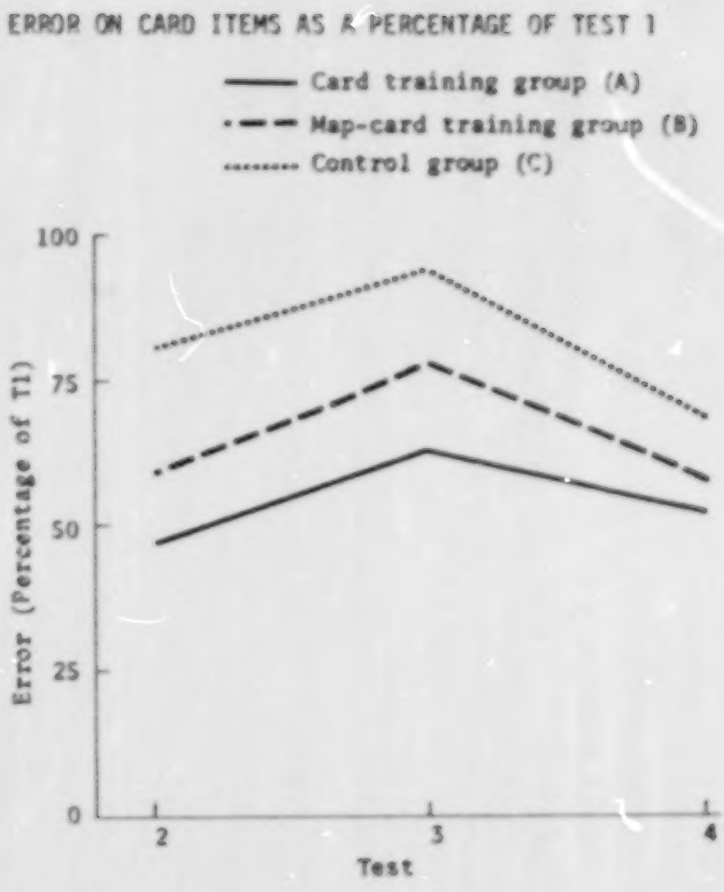


Figure 8

Table 3

PROBABILITY LEVELS FOR DIFFERENCES BETWEEN PAIRS OF TESTS[a]

Group	Test	Map Items			Card Items		
		T2	T3	T4	T2	T3	T4
Card Training Group (A)	T1	.03	.22	.03	.03	.69	.22
	T2		.69	.69		.22	.69
	T3			.69			.38
Card-Map Training Group (B)	T1	.03	.03	.03	.03	.69	.03
	T2		.22	.22		.22	.69
	T3			.99			.69
A and B Combined	T1	.01	.01	.01	.01	.39	.01
	T2		.77	.77		.04	.39
	T3			.77			.23
Control Group (C)	T1	.06	.22	.06	.22	.69	.22
	T2		.69	.38		.99	.22
	T3			.99			.38

[a]*Probabilities are based on results of a sign test.*

Mann-Whitney *U* tests[1] on the ratio data indicated that test performance of the two training groups on map items was significantly superior to test performance of the control group on map items for Tests 2, 3, and 4. On card items there were no significant differences between the two training groups and the control group. There were no significant differences between the two training groups on either card items or map items. Specific probability levels for the differences between pairs of groups are shown in Table 4.

These results have been based on magnitude of error without consideration of direction of error, that is, overestimation or underestimation of angle size. Figures 9 and 10 and Table 5 show mean algebraic error for the three groups for map and card items, respectively. These data show that training produced differential effects on map and card item performance. On Test 1 both training groups tended to underestimate angle size for both map and card items. After training, the training groups continued to underestimate angles on Test 2 and Test 3 for card items, but changed to overestimating on map items. The differences in post-training performance between map and card items were tested by *t* test and found to be significant for both Test 2 and Test 3 ($p<.01$).

Figure 11 shows mean algebraic error by angle size on Tests 2 and 3 combined for the two training groups combined. These data indicated that after training, over the range of angle sizes

[1]S. Siegel, *Nonparametric Statistics for the Behavioral Sciences*, McGraw-Hill Book Company, Inc., New York, 1956.

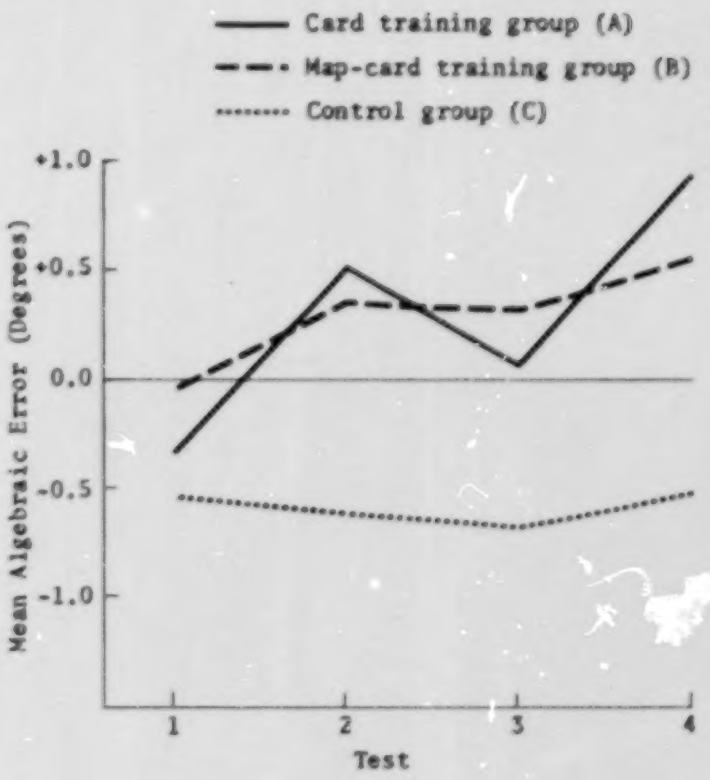


Figure 9

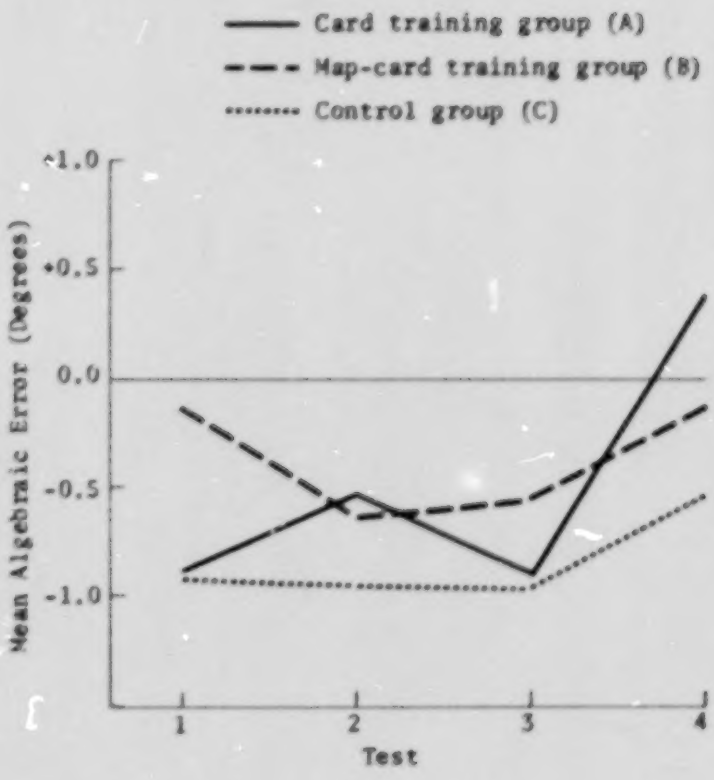


Figure 10

MEAN ALGEBRAIC ERROR AFTER TRAINING FOR MAP AND CARD ITEMS BY ANGLE SIZE

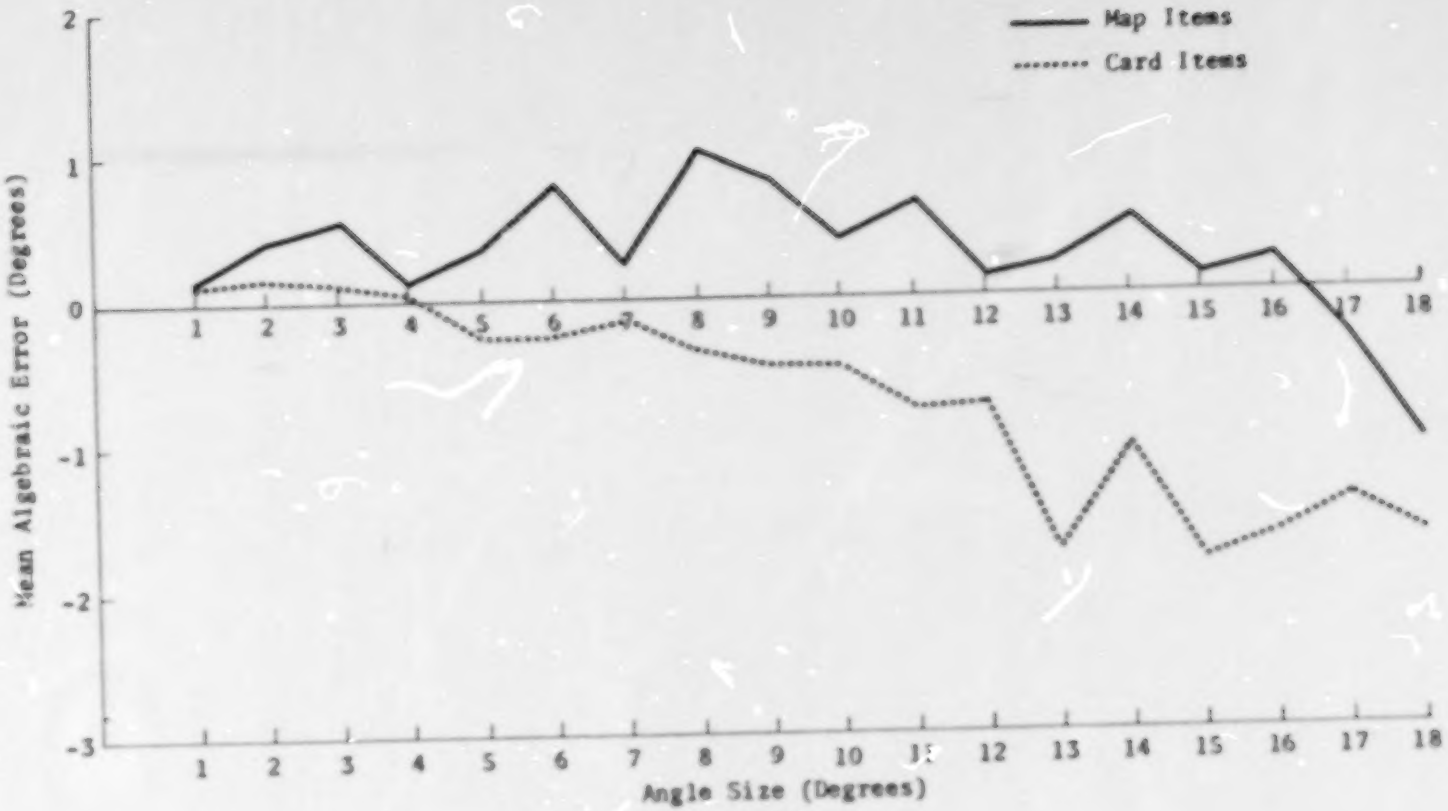


Figure 11

Table 4

PROBABILITY LEVELS FOR DIFFERENCES BETWEEN TRAINING AND CONTROL GROUPS FOR PERFORMANCES ON TESTS 2, 3, AND 4 AS COMPARED WITH TEST 1[a]

Test Compared with T1	Group	Map Items		Card Items	
		B	C	B	C
T2	A	.20	.07	.47	.16
	B		.09		.35
	A&B		.05		.17
T3	A	.41	.09	.47	.29
	B		.12		.41
	A&B		.06		.29
T4	A	.35	.02	.35	.47
	B		.07		.24
	A&B		.02		.29

[a]*Probabilities are based on a Mann-Whitney U test.*

Table 5

MEAN ALGEBRAIC ERROR ON MAP AND CARD ITEMS

Group	Map Items				Card Items			
	T1	T2	T3	T4	T1	T2	T3	T4
A	-.36	+.52	+.08	+.94	-.89	-.56	-.90	+.35
B	-.04	+.35	+.32	+.55	-.20	-.66	-.58	-.19
A & B	-.20	+.43	+.20	+.75	-.55	-.61	-.74	+.08
C	-.52	-.63	-.70	-.51	-.93	-.95	-.95	-.56

studied, there was a generally consistent tendency toward underestimation of the size of angles for card items and toward overestimation for map items.

Figure 10 shows that the underestimation tendency for card items changed to overestimation on Test 4, apparently as a result of using the job aid. A *t* test on the difference between Test 3 and Test 4 indicated it to be significant ($p<.01$).

The performance of the control group, by contrast, remained consistent over all four tests. The control group tended to underestimate angle size.

DISCUSSION

Subjects in this experiment exhibited different levels and patterns of performance on map items as compared to their performance on card items. In actual practice, the pilot's task is to

determine heading changes from information presented on a map. Therefore, test performance on map items provides the most relevant basis for a decision on the feasibility of using direct estimation as a technique for determining correction angles.

The performance of both training groups on map items improved markedly after training. Before training, subjects estimated angle sizes on maps with a mean error of 2.57°. Immediately following training, the same subjects estimated angles on maps with a mean error of 1.34°, for a reduction in error of 48%. The control group showed only about 15% reduction in error on the second test.

The slight improvement of the control group with the practice provided by testing probably derives from the fact that all subjects were informed in the initial instructions that no test angle would be larger than 18°. Since the subjects in the control group knew that the largest angle was 18°, as the test progressed they probably developed a frame of reference upon which they based their later judgments. Therefore, it is not surprising that the control group showed a slight, though not significant, decrease in estimation error.

In this connection, it may be noted that the overall test results (Table 1) showed that for the trained subjects the $\frac{\text{Test 2 error}}{\text{Test 1 error}}$ ratio decreased as angle size increased. The untrained subjects showed very little improvement on retesting for the small angles, but did exhibit a small reduction in error on the large angles. This was probably due to the frame of reference established from the knowledge that the maximum angle size was 18°. Trained subjects, on the other hand, showed an increase in error ratio as angle size increased.

Performance on map items did not significantly deteriorate after one week. The lack of serious deterioration in performance over this period of time was particularly notable because the average training time for subjects in the training groups was only 24 minutes.

Since there were no significant differences between the two training groups on Test 2, 3, or 4, a choice between card and card-map training should be based on something other than the relative performance of the two training groups. In view of the differences in performance that were noted between card and map test items, it would seem desirable to conduct the training program entirely with map items. This would also be in accord with the generally desirable goal of keeping training as realistic as is practical.

The job aid did not improve performance on map items on the fourth test for either of the training groups or for the control group. That performance did not improve was contrary to expectations, particularly for the control group. In this experiment, subjects were not given the job aid until the last test, one week after the training session. Therefore, no conclusion can be drawn relative to the possible effect of providing a job aid before, during, or immediately after training.

Several considerations are important in determining whether or not to provide training in angle estimation to pilots. First, is there any actual value to training? Post-training error on map items was almost 50% lower than pretraining error in this experiment. Such a reduction should be of practical value. Second, mean error after training was only 1° to 1.5°, which indicated that trained subjects should be capable of estimating drift angle sizes with sufficient accuracy for correcting off-course situations. Finally, the training material used in this experiment was relatively simple and inexpensive to prepare, it could be easily distributed and administered, and it was studied for an average of only 24 minutes per subject. Thus, it appears that angle estimation training produces an improvement in skill that is feasible and desirable for operational use.

Though the job aid did not improve performance on map items, use of a job aid might result in maintaining positive training effects over periods of time longer than one week. However, further research would be necessary to establish the value of a job aid over long periods of time or to determine the effects of using the job aid during training. In any case, the cost of providing a suitable job aid would be negligible because the face of a radio compass or gyro compass in the aircraft could serve the purpose.

Appendix

INSTRUCTIONS FOR THE THREE GROUPS

Introduction to the Experiment for All Three Groups

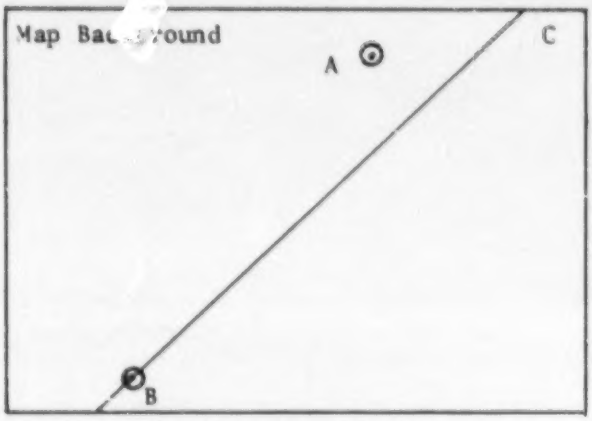
Please open the notebook before you to the first page and follow along as I read the instructions.

The purpose of the experiment in which you are about to participate is to determine how accurately people can identify angle size without the benefit of mechanical aids. Don't let the bulk of the booklets mislead you. Each test lasts only 12 minutes. The entire session will take about an hour, including rest periods and instructions.

You will be given a series of three tests; each test will have 72 items. Each item will consist of an angle presented on a card or map section which you are to examine. When you have examined the angle, you must then write your estimate of the angle size in the proper blank on the answer sheet. All of the angles fall within 1° to 18°. They may be oriented in any direction.

You will be allowed 10 seconds in which to study an angle and record your response. The experimenter will time you. You will find that 10 seconds is more than adequate time. When he says "next" you must move to the next item. There will be two items per page, one on each side. You *must* answer every question. Some of the angles will be drawn on cards and some will be drawn on maps. The angles drawn on maps have only one complete side, but they have a dot with a circle around it to represent the extent of the angle and its origin.

In the example of a map item you can see a straight line drawn across the map, a dot and circle on the straight line labeled B, and a dot and circle away from the line labeled A. You are to estimate the angle which could be formed by ABC. In other words, you are to estimate the size of the angle that would be formed if a line were drawn from A to B. You are to use the center of the dot as a reference point in estimating the angle. The circle around the dot is not accurate but will help you to find the dot.



Example of a Map Item

A heavy black line has been drawn at the origin of every angle on the maps to help you find it. You may find it necessary to search for the dot representing the side of the angle, but you can be sure that it is there somewhere not too far from the line. One full size example of each type item is shown on the next page [see page 5 of this report].

You are to write your answer to the nearest degree. Do not estimate any angle to a half degree.

Do not look back at items already answered. Do not change an answer once you have recorded it. Look at the angle as it is oriented on the page; i.e., don't turn the book sideways.

Remember:

1. You have 10 seconds to answer each question.
2. You must answer every item--a wild guess, if necessary.
3. All angles fall within 1° to 18°, inclusive; i.e., some angles will be 1°, some will be 18°.
4. Estimate by the dot, not by the circle.
5. Your first reaction may be your best bet.
6. Be careful to put your answer in the right blank on the answer sheet.

On the next few pages are five examples of the test questions. Turn to them now and write down your estimate of each one. The experimenter will answer any question that you might have. You will *not* be told the size of the angle on the examples or on any of the test questions.

[At this point, five examples were presented.]

Remember:

1. You have 10 seconds to answer each question. I will indicate when you are to go to the next item by saying "Next."
2. You must answer every item--a wild guess, if necessary.
3. All angles fall within 1° to 18°, inclusive; i.e., some angles will be 1°, some will be 18°.
4. Estimate by the dot, not by the circle.
5. Your first reaction may be your best bet.
6. Be careful to put your answer in the right blank on the answer sheet.

If you have any questions, ask the experimenter now. Once the test begins, please do not talk. If you are positive that you understand the procedure, tell the experimenter now, and get ready to start. Do not turn to the first item until the experimenter says "Go."

Instructions for the Study Session for the Training Group

This is not a test; this is a study session. The purpose of this study session is to help you learn to recognize the size of angles from 1° through 18°. First, you will be shown three angles, 5°, 10°, and 15° in two different orientations. You may compare them as long as you wish. Then, you will be given a series of

angles to identify. As you look at each angle and estimate it, write down your estimate in the first blank opposite the corresponding number on the answer sheet. Next, lift up the tab at the bottom of the page. Under the tab will be shown the correct size of the angle. Read the correct size and look at the angle again. If you have identified the angle correctly, go right on to the next one. If you did not identify the angle correctly, draw a line through your incorrect answer. Then, write the correct answer in the second space on the answer sheet. When you have done that, go on to the next question.

Some of the items will be on cards, and some will be on maps.[1] Don't worry about how close you come to being correct. You will not be timed on each item, but your total time for the study session will be recorded. Work as accurately as you can, but do not waste time. Remember, you can look at the first set of angles as long as you like, but you may not turn back to it. Nor may you turn back to any angle which you have already identified.

In summary, your procedure is this:

A. Study the first set of angles.
B. Study the series that follows.
   1. Look at an angle and estimate its size.
   2. Record your estimate in the first space on the answer sheet.
   3. Lift up the tab and read the correct size.
   4. If correct, proceed to the next angle.
   5. If incorrect, look at the angle again.
   6. Cross out your wrong response and write the correct size in the second space.
   7. Proceed to the next question.

If you have no questions about the study procedure, you may begin. Be as accurate as possible, but do not waste time.

Instructions for the Control Group

For the next 30 minutes you are to rest and engage in activities unrelated to angle recognition.

For the first five minutes you will be free to do whatever you please. You may read, get some coffee, or just wait; but you are not to do anything related to angles or angle recognition.

Then for 20 minutes you *must* sit at the table. You may look at the *National Geographic* magazines or you may sit quietly, but you must sit at the table.

For the last five minutes you will again be free to do whatever you wish within the limits stated above.

Do you have any question about the next 30 minutes?

Instructions for T3 for All Three Groups

This test will be conducted just like the first test you had last week. There are 72 items; you will be given 10 seconds on

[1] For the group trained on cards, this sentence was changed to read: "All of the items will be on cards."

each one. I will indicate when you are to go to the next question by saying "Next."

Do not change answers or use your pencil as a measuring aid.

Instructions for T4 for All Three Groups

On this last test you will be provided a card with three angles drawn on it: 5°, 10°, and 15°. You may keep this card before you throughout the test and use it as a reference. Please notice that the sides of the angles on the reference card are shorter than the sides of the angles on the tests. Before the test begins you may examine the reference card as closely as you wish. However, once the test begins please do not move it from its position on the table, nor move from your chair to get closer to the card.

Except for the use of the card, the procedure on this test will be the same as on previous tests. You will, as before, be given 10 seconds on each item. Please do not change answers.

Any questions?

Unclassified
Security Classification

DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author)
Human Resources Research Office,
The George Washington University,
Alexandria, Virginia 22314

2a. REPORT SECURITY CLASSIFICATION
Unclassified

2b. GROUP

3. REPORT TITLE
THE EFFECT OF TRAINING ON ACCURACY OF ANGLE ESTIMATION

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Technical Report

5. AUTHOR(S) (Last name, first name, initial)
Waller, T. Gary, and Wright, Robert H.

6. REPORT DATE
Aug 65

7a. TOTAL NO. OF PAGES
32

7b. NO. OF REFS

8a. CONTRACT OR GRANT NO.
DA 44-188-ARO-2

b. PROJECT NO.
2J024701A712 01

c.

d.

9a. ORIGINATOR'S REPORT NUMBER(S)
Technical Report 65-8

9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. AVAILABILITY/LIMITATION NOTICES
Distribution of this document is unlimited.

11. SUPPLEMENTARY NOTES
Methods for Improving Navigation Training for Low Altitude Flight

12. SPONSORING MILITARY ACTIVITY
The Department of the Army,
Office, Chief of Research and Development,
Washington, D.C. 20310

13. ABSTRACT
This study examined the feasibility of using direct perceptual estimation on maps to determine angles of drift, and the effect of training on this ability. Subjects were divided into a control group and two training groups, one of which was trained using angles drawn on plain white cards, and the other using angles drawn on both cards and tactical maps. Both training groups initially estimated the size of angles, ranging from 1° to 18°, with a mean absolute error of 2.57° and a mean algebraic error of -0.20°. After training, absolute error was 1.34° and algebraic error was +0.43°. A job aid consisting of reference angles of 5°, 10°, and 15° did not significantly affect performance on map items, although on card items, performance of the training groups shifted from underestimation to slight overestimation of angle size.

DD FORM 1 JAN 64 1473

Unclassified
Security Classification

Unclassified

Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Navigation Angle Estimation Military Training Map Reading Aerial Navigation Training						
COSATI Field 5 Div. 19, 23						

INSTRUCTIONS

1. ORIGINATING ACTIVITY: Enter the name and address of the contractor, subcontractor, grantee, Department of Defense activity or other organization *(corporate author)* issuing the report.

2a. REPORT SECURITY CLASSIFICATION: Enter the overall security classification of the report. Indicate whether "Restricted Data" is included. Marking is to be in accordance with appropriate security regulations.

2b. GROUP: Automatic downgrading is specified in DoD Directive 5200.10 and Armed Forces Industrial Manual. Enter the group number. Also, when applicable, show that optional markings have been used for Group 3 and Group 4 as authorized.

3. REPORT TITLE: Enter the complete report title in all capital letters. Titles in all cases should be unclassified. If a meaningful title cannot be selected without classification, show title classification in all capitals in parentheses immediately following the title.

4. DESCRIPTIVE NOTES: If appropriate, enter the type of report, e.g., interim, progress, summary, annual, or final. Give the inclusive dates when a specific reporting period is covered.

5. AUTHOR(S): Enter the name(s) of author(s) as shown on or in the report. Enter last name, first name, middle initial. If military, show rank and branch of service. The name of the principal author is an absolute minimum requirement.

6. REPORT DATE: Enter the date of the report as day, month, year; or month, year. If more than one date appears on the report, use date of publication.

7a. TOTAL NUMBER OF PAGES: The total page count should follow normal pagination procedures, i.e., enter the number of pages containing information.

7b. NUMBER OF REFERENCES: Enter the total number of references cited in the report.

8a. CONTRACT OR GRANT NUMBER: If appropriate, enter the applicable number of the contract or grant under which the report was written.

8b, 8c, & 8d. PROJECT NUMBER: Enter the appropriate military department identification, such as project number, subproject number, system numbers, task number, etc.

9a. ORIGINATOR'S REPORT NUMBER(S): Enter the official report number by which the document will be identified and controlled by the originating activity. This number must be unique to this report.

9b. OTHER REPORT NUMBER(S): If the report has been assigned any other report numbers *(either by the originator or by the sponsor)*, also enter this number(s).

10. AVAILABILITY/LIMITATION NOTICES: Enter any limitations on further dissemination of the report, other than those imposed by security classification, using standard statements such as:

(1) "Qualified requesters may obtain copies of this report from DDC."

(2) "Foreign announcement and dissemination of this report by DDC is not authorized."

(3) "U. S. Government agencies may obtain copies of this report directly from DDC. Other qualified DDC users shall request through _____."

(4) "U. S. military agencies may obtain copies of this report directly from DDC. Other qualified users shall request through _____."

(5) "All distribution of this report is controlled. Qualified DDC users shall request through _____."

If the report has been furnished to the Office of Technical Services, Department of Commerce, for sale to the public, indicate this fact and enter the price, if known.

11. SUPPLEMENTARY NOTES: Use for additional explanatory notes.

12. SPONSORING MILITARY ACTIVITY: Enter the name of the departmental project office or laboratory sponsoring *(paying for)* the research and development. Include address.

13. ABSTRACT: Enter an abstract giving a brief and factual summary of the document indicative of the report, even though it may also appear elsewhere in the body of the technical report. If additional space is required, a continuation sheet shall be attached.

It is highly desirable that the abstract of classified reports be unclassified. Each paragraph of the abstract shall end with an indication of the military security classification of the information in the paragraph, represented as *(TS)*, *(S)*, *(C)*, or *(U)*.

There is no limitation on the length of the abstract. However, the suggested length is from 150 to 225 words.

14. KEY WORDS: Key words are technically meaningful terms or short phrases that characterize a report and may be used as index entries for cataloging the report. Key words must be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location, may be used as key words but will be followed by an indication of technical context. The assignment of links, roles, and weights is optional.

Unclassified

Security Classification

DISTRIBUTION LIST

2 DIR OF RES HUM RQ DIR NO 1 SYS OPS
2 DIR OF RES HUMRO DIR NO 7 LNO
1 MILIT ADV HUMAN R CTORS + OPNS RES DIR ARMY RES OFC HUMRRO
5 DIR OF RES HUMRRO DIV NO 2 ARMOR FT KNOX
5 DIR OF RES HUMRRO DIV NO 3 RECRUIT TNG PROG OF MONTEREY
5 DIR OF RES HUMRRO DIV NO 4 INF FT BENNING
5 DIR OF RES HUMRRO DIV 5 AIR DEF FT BLISS
2 DIR OF RES HUMRRO DIV NO 6 AVN FT RUCKER
10 CG US CONARC FT MONROE ATTN DCS IT
1 CHF INF FT ATTN SCI INFO BR RES SPT DIV
2 HUMAN FACTORS + OPNS RES DIV ARMY RES OFC OFC CHF OF RAD
2 DIR MANPOWER REQUIREMENTS + UTILIZATION DASD MANPOWER SS+R
1 DIR WEAPONS SYS EVAL OP
1 COMDR FLD COMD DEF ATOMIC SPT AGY SANDIA BASE ATTN PCTGT
4 SCI + TECH INFO FACILITY ATTN NASA REP S+A-DL
1 CENC US ARMY PACIFIC APO 958 SAN FRAN ATTN G3 LBT DEVEL DIV
1 CG SOUTHERN EUROPEAN TASK FORCE APO 168 NY
1 CG US ARMY JAPAN APO 343 SAN FRAN ATTN G3
2 CG US ARMY CARIBBEAN APO 834 N ORLEANS ATTN CARLO
1 CG US ARMY ALASKA APO 942 SEATTLE ATTN ARACO
2 CG US ARMY EUROPE APO 403 NY ATTN OPNS DIV
1 CO ARMY TRANS RES COMD FT EUSTIS ATTN TECH LIB
6 CG FIRST ARMY GOVERNORS ISL NY ATTN G3
4 CG SECOND ARMY FT GEO G MEADE ATTN DCSOT
1 CG THIRD ARMY FT MCPHERSON
1 CG FOURTH ARMY FT SAM HOUSTON ATTN G3
7 CG FIFTH ARMY CHICAGO ATTN AVIAT TNG
1 CG SIXTH ARMY PRES OF SAN FRAN ATTN ARARA
1 HQ SEVENTH ARMY OFC OF CHIEF OPNS APO 46 NY
1 CG EIGHTH ARMY APO 301 SAN FRAN ATTN AVIAC
1 CLIN PSYCHOL SERV DEPT OF NEUROPSYCHIAT WALTER REED GEN HOSP
1 DIR HUMAN ENGNG LABS ABERDEEN PG
2 ENGNG PSYCHOL LAB PIONEERING RES DIV ARMY NATICK LABS NATICK MASS
1 TECH LIB ARMY NATICK LABS NATICK MASS
1 CO ARMY PICTORIAL CTR LONG ISL CITY ATTN APPLICAT DEVEL BR TV DIV
1 CG ARMY ELEC PG FT HUACHUCA ATTN TECH LIB
12 CO 1ST AIR DEF GUIDED MSL BRDD TNG FT BLISS
1 CG ARMY LBT DEVEL COMD EXPER CTR FT ORD
1 SIXTH ARMY LIB DEPOT PRES OF SAN FRAN
1 CO FT ORD ATTN GS TNG DIV
1 DIR WALTER REED ARMY INST OF RES WALTER REED ARMY MED CTR
1 DIR WALTER REED ARMY INST OF RES WALTER REED ARMY MED CTR
ATTN NEUROPSYCHIAT DIV
1 CO HQ ARMY ENLISTED EVAL CTR FT BENJ HARRISON
1 DEP FOR BIOASTRONAUT PG AIR FG CTR EGLIN AFB
1 CO PLANSFORD ARSNL ATTN SMUFA 1031/64-1
2 WALTER REED ARMY INST OF RES ATTN DEPT OF PSYCHIAT NEUROPSYCHIAT DIV
1 CG 97TH AUN USARAIC&M FT SHERIDAN ATTN G3 TNG
1 6TH AUN USARAIC&M FT BAKER
2 11TH AIR ASSAULT DIV FT BENNING
1 FORS SUBSYS DIV CREW SUBSYS OBJT AERONAUT SYS DIV WRIGHT-PATTERSON AFB
1 DIR ARMY RD FOR AVN ACCIDENT RES FT RUCKER
1 CHIEF ARMY MSL COMD RED APO 731 NY
2 CO PICATINNY ARSNL DOVER N J ATTN SMUFA VC1
1 DEP SUPPLY AGY CAMERON STATION ATTN L1B
1 CO ARMY LBT DEVEL COMD FT ORD HARRISON ATTN ADJ GEN AGY
1 LBT OPNS RES OF ARMY LBT DEVEL COMD FT BELVOIR
ATTN OPNS ANLS HUMAN FACTORS
1 CO ARMY LBT DEVEL COMD FT BENNING ATTN INF AGY
1 CO ARMY LBT DEVEL COMD FT KNOX ATTN ARMOR AGY
8 ARMY EST DEVEL COMD FT BRAGG ATTN SPEC WARFARE AGY
1 EVAL DIV DAD ARMY SIG CTR + SCH FT MONMOUTH
1 CHF CURRICULUM RR RESIDENT INSTR DEPT ARMY LOGISTICS MGMT CTR FT LEE
1 CO ARMY LBT DEVEL COMD SOEL DOCTRINE + EQUIPMENT GP FT BELVOIR
2 LEVLN PERS OFCR US ARMY SPT CTR ST - FORTS ATTN INDU - C DEVEL OFCR
1 ARMY WAR COLL CARLISLE BKS ATTN L1B
1 ASST COMDT ARMY INTEL SCH FT HOLABIRD ATTN PLANS DIV DAO
1 COMDT COMD + GEN STAFF CO FT LEAVENWORTH ATTN ARCHIVES
1 DIR OF MILIT PSYCHOL + LORSHIP US MILIT ACAD WEST POINT
1 US MILIT ACAD WEST POINT ATTN L1B
1 COMDT ARMY AVN SCH FT RUCKER ATTN SCH L1B
2 COMDT ARMY SIGNAL BCH TNG CEN + SCH FT GEORGE ATTN L1B
1 COMDT ARMED FORCES INDSTR COLL FT LESLEY J MCNAIR
1 COMDT NATL WAR COLL FT LESLEY J MCNAIR ATTN CLASSF RECORDS RR L1B
1 MED FLD SERV SCH BRIDGE ARMY MED CTR FT SAM HOUSTON ATTN STENSON L1B
10 DIR OF INSTR ARMOR SCH FT KNOX
1 COMDT ARMY ARMOR SCH FT KNOX ATTN WEAPONS DEPT
1 COMDT ARMY CHAPLAIN SCH FT HAMILTON
1 COMDT ARMY CHEM CORPS SCH FT MCCLELLAN ATTN DDUC ADV
1 ARMY FINANCE SCH FT BENJ HARRISON
1 COMDT ARMY ADJ GEN SCH FT BENJ HARRISON ATTN DDUC ADV
1 ARMY INF SCH FT BENNING ATTN DDUC ADV
1 COMDT HQ ARMY ADJ GEN SCH FT BENJ HARRISON
1 ARMY QM SCH FT LEE ATTN L1B
1 COMDT ARMY QM SCH FT LEE ATTN DDUC ADV
1 COMDT ARMY TRANS SCH FT EUSTIS ATTN DDUC ADV
1 COMDT ARMY MILIT POLICE SCH FT GORDON ATTN DIR OF INSTR
1 COMDT ARMY SOUTHEASTERN SIG SCH FT GORDON
1 CG ARMY ORD CTR + SCH ABERDEEN PG ATTN AISO-SL
1 ASST COMDT ARMY AIR DEF SCH FT BLISS ATTN CLASSF TECH LIB
10 CG ARMY ARTY + MSL CTR FT SILL ATTN ANN OFFR
1 COMDT ARMY DEF INTEL SCH ATTN S+AS DEPT
1 COMDT ARMED FORCES STAFF COLL NORFOLK
1 COMDT ARMY SIG SCH FT MONMOUTH ATTN DDUC LOGRO
1 COMDT JUDGE ADVOCATE GEN SCH U OF VA
1 DDUC CONSLT ARMY MILIT POLICE SCH FT GORDON
1 COMDT ARMY ENGNR SCH FT BELVOIR ATTN AIBSES-SE
1 LNDO US ARMY SCH EUROPE APO 172 NY ATTN ROT L1B
1 CHF POLICY + TNG LIT DIV ARMY ARMOR SCH FT KNOX
1 COMDT ARMY AVN SCH FT RUCKER ATTN DDUC ADV
1 COMDT ARMY PRINT-MEL SCH FT MONROE
1 DIR OF MILIT INSTR US MILIT ACAD WEST POINT
1 CHF WARFARE SCH FT BRAGG ATTN L1B
1 ARMY SIG CTR + SCH FT MONMOUTH ATTN TNG LIT DIV DAO
2 SELF ARMY ORDNANCE GUIDED MISSILE SCH REDSTONE ARSNL
2 COMDT WOMENS ARMY CORPS SCH + CTR FT MCCLELLAN
2 HQ ABERDEEN PG ATTN TECH LIB
1 COMDT ARMY QM SCH DDC DIR OF NONRESID ACTVT FT LEE ATTN TNG MEDIA DIV
2 DIR BRDD + BN OPNS DEPT USAES FT BENNING
2 DIR COMPANY TACTICS DEPT USAES FT BENNING
1 SECY OF ARMY
1 DCS-PERS DA ATTN CHF CAS DIV
2 DACS FOR INTEL DA ATTN CHF CST INTEL DEVEL DIV
1 CO FOREIGN SCI + TECH CTR MUN BLDG
2 ASST COM FORCE DEVEL DA ATTN CHF TNG DIV
1 CHF OF ENGNRS DA ATTN ENLTS-T
1 HQ ARMY MAT COMD RQS DELTE ATTN AMCRD-RC
2 CG ARMY MED R+D COMD ATTN MCHAR SCI SEC SG
1 ARMY PERS RES OFC ATTN CPO-RS
2 OFC OF PERS OPNS DA ATTN DPCS+A
1 STANDARDS + SYS DEV AND OCCUP R+D SECT ATTN DPOSS-A
1 ARMY PROVOST MARSHAL GEN
1 DIR CIVIL AFFAIRS DELTE DCSS-OPNS DA
1 OPO RESERVE COMPON DA
2 CHF ARMY SIGLAB AGY ARLINGTON HALL STA ATTN ACS-01
20 CHF DEP DOCUMENTATION CTR CAMERON STA
1 CG ARMY ELSCT COMD FT MONMOUTH ATTN AMSEL CS
1 CHF OF R+D DA ATTN CHF TECH + INDSTR LIAISON OFC
1 DDUC + TNG BR CBT DEVEL + OPNS DIV OFC OF CHF SIG OFFR DA
1 PERS + TNG DIV DRDMC OFC OF CHF OF ORD DA
2 CG ARMY MED R+D COMD ATTN MEDDH-SR
1 ARMY PERS RES OFC ATTN CPO-AEC
1 COMDT ARMY CBT SURVEIL SCH FT HUACHUCA ATTN AVIAN SS
1 CG ARMY AIR DEF COMD ENT AFB
1 TNG + DEVEL DIV DCSS-PERS
1 MESS ARMY ARMOR BD FT KNOX
1 MESS ARMY MAINT BD FT KNOX
2 MESS ARMY AVN TEST BD FT RUCKER
2 MESS ARMY ARTY BD FT SILL
1 OFFR MESS ARMY MAT COMD BD ABERDEEN PG
1 MESS ARMY TRANS BD FT EUSTIS
1 CO ARMY CBT DEVEL COMD MILIT POLICE A+E FT GORDON
1 CG 7D ARMORED DIV FT HOOD ATTN DIV AVN OFCR
1 CG 4TH ARMORED DIV APO 126 NY
1 CO 4TH ARMOR GP APO 757 NY
2 CO 66TH ARMOR GP FT JENIN
1 CO 2D ARMORED CAV REGT APO 696 NY
1 CO 3D ARMORED CAV REGT APO 36 NY
6 CO 11TH ARMORED CAV REGT APO 509 NY
1 CO 14TH ARMORED CAV REGT APO 26 NY
2 CG ARMY ARMOR + ARTY FIRING CTR FT STEWART ATTN ACS-GS TNG OFCR
1 1ST ARMORED DIV HQ+HD CO FT HOOD ATTN ALSIG2
1 1ST CAV DIV 3D MED TANK BN 40TH ARMOR APO 24 SAN FRAN
10 1ST INF DIV 1ST MED TANK BN 81D ARMOR FT RILEY
1 3D INF DIV 1ST BN 66TH ARMOR APO 36 NY
2 10TH 1ST BN 56TH ARMOR FT LEWIS
2 1ST TANK BN 73D ARMOR 7TH INF DIV APO 7 SAN FRAN
8 8TH INF DIV 2D BN 68TH ARMOR APO 36 NY
1 CO COMPANY A 3D BN 32D ARMOR 5D ARMORED DIV LAKEARHEADS APO 58 NY
1 CO 9TH BN 3RD ARMOR FT KNOX
1 CO 3D MED TANK BN 68TH ARMOR APO 28 NY ATTN S3
1 CO 5D MED TANK BN 11TH ARMOR APO 36 NY
1 CO 4TH MED TANK BN 68TH ARMOR APO 28 NY
1 CO 2D BN 34TH ARMOR FT IRWIN
2 CALIF NG 40TH ARMORED DIV LOS ANGELES ATTN ACS-GS
1 55TH CORD HQ DIV ARMY NG JACKSONVILLE FLA
4 CO 150TH ARM BN NJ AIR NG ELIZABETH
1 CG HQ 27TH ARMORED DIV NY AIR NG SYRACUSE
1 TEXAS NG 49TH ARMORED DIV DALLAS
2 CO 3D MED TANK BN 32D ARMOR APO 29 NY
1 CG ARMY ARMOR CTR FT KNOX ATTN G3 AIRBGT
2 CG 1ST INF DIV FT RILEY ATTN G3
1 CG 2D INF DIV FT BENNING ATTN DIV AVN COORD
1 CG 4TH INF DIV FT LEWIS ATTN G3
1 CG 8TH INF DIV APO 111 NY ATTN G3
1 CG 5TH INF DIV INFCHIEF FT CARSON
1 CG 24TH INF DIV APO 112 NY ATTN G3
1 CG HQ US ARMY HAWAII APO 957 SAN FRAN ATTN G3
1 CG 82D ABN INF DIV FT BRAGG ATTN G3
1 CO 1ST BN 3RD INF 1 SD INF 173D SLD AIRBDE FT MYERS
1 CO HQ 2D BN 8TH INF BRIGT APO 742 NY
1 CO 3D BN 8TH INF BRIGT APO 742 NY
1 CO 17TH INF BRIGD APO 731 SEATTLE
1 CG 25TH INF DIV APO 25 SAN FRAN
1 CO 2D BG 1ST INF POST FT RUCKER
1 CO 3D BN 34TH INF APO 24 NY
1 CO 1ST BN 50TH INF APO 24 NY
4 CO 1ST BN 3RD INF 5TH INF 1ST ARMORED DIV COLD IRONSIDES FT HOOD
1 4TH BN 3RD INF 5TH INF FT KNOX
1 CO ARMY PARTIC GP NAV TNG DEVICE CTR FT WASHINGTON ATTN CODE 214
1 CO HQ ARMY AERIALSCATTYG + VISUAL ALERT PACIFIC APO 331 SAN FRAN
ATTN FUEL PROJ OFC
2 CHF AUDIO VISUAL APPLICAT OFC ARMY PICTORIAL DIV OFC OF CHF SIG OFCR
1 CHF RES RES PROJ ARMY HOUS US MILIT ACAD WEST POINT
1 CG MILIT DIST OF WASHINGTON
1 TECH DIR RES DIV OFC OF CH GEN
2 HQ ARMY LIAISON OF PROJ MICH U OF MICH
1 DIR ARMY LIB
1 STRATEGIC PLANNING GP LORDS OF ENGNG ARMY MAT SERV
1 CHF OF MILIT HIST DA ATTN GEN REF BR
1 820 ABN DIV FT BRAGG
5 HQ 40TH ARTY BRIG AIR DEF PERS OF SAN FRAN
1 CO 96TH ARTY BRIGD AIR DEF FT BANKS
1 CG 31ST ARTY BRIGD AIR DEF CARLISLE PENNA
1 26TH ARTY GP AIR DEF FT LAWTON
2 HQ 4/56TH ARTY HAMPTON ROS ARMY TERM NORFOLK
1 28TH ARTY GP AIR DEF SELFRIDGE AFB
1 52D ARTY BRIGD AIR DEF HIGHLANDS ASS
1 HQ 45TH ARTY BRIGD AIR DEF ARLINGTON HTS ILL
1 59TH ARTY BRIGD AIR DEF FT GEO G MEADE
1 CO ARMY AVN TEST BD FT RUCKER
1 CO 3D1ST ABN DIV FT CAMPBELL
1 CG 1ST CAV DIV APO 24 SAN FRAN
1 ARMY QM R+D CEN FT LEE ATTN TECH LIB
1 CHF BUWEPS SEA RES SK ARMY MED R+D COMD
2 PRES ARMY FINANCE CORPS BR
1 ARMY R+D OFC PENTAG FT CLAYTON LANAL ZONE ATTN BUWEPS SEA COMRD
2 CENC US PACIFIC FLT PHD SAN FRAN
1 CENC PACIFIC OPNS ANLYS SECT PHD SAN FRAN
1 CHF BUR OF MED + SURG ON ATTN CODE 513
1 HEAD CLIN PSYCHOL SECT PROFESNL DIV BUR OF MED + SURG DN
1 BUR OF NAV PERS ATTN TECH LIB PERS 11B
1 DIR PERS RES DIV BUR OF NAV PERS
1 CHF OF NAV PERS
1 CHF OF NAV PERS ATTN PERS-C1171
1 CO + DIR NAV TNG DEVICE CTR FT WASHINGTON ATTN L1BR
2 NAV MSL CTR POINT MUGU CALIF ATTN HUMAN FACTORS ENGNG DIV
1 CO NAV AIR DEVEL CTR JOHNSVILLE PENNA ATTN NADC 11B
2 FLT ANTI-AIR WARFARE TNG CTR OAK NECK VA BEACH
2 CO FLT TNG CTR NAV BASE NORFOLK
2 DIC ATLANTIC FLT MSL WEAPON SYS TNG UNIT FLT ANTI-AIR WARFARE TNG CT
OAK NECK VA BEACH

1 CO FLT TNG CTR NORFOLK
1 HUMAN FACTORS DEPT CODE 2300 PSYCHOL DIV NAV TNG CENTER ORLANDO
1 CLIN PSYCHOL MENTAL HYGIENE UNIT US NAV ALAD ANNAPOLIS
1 PERS RES NAV COLL NEWPORT ATTN MANAN LIB
2 CO COMB ATLANTIC FLT ANTI-SUB WARFARE TACTICAL SCH NORFOLK
1 CO WALLOP WEAPONS TNG CTR ATLANTIC NAV AIR STA NORFOLK
2 CO 2+I ANTI-AIR WARFARE TNG CTR OAK HAIK ST BEACH
2 CO FLT SONAR SCH KEY WEST
1 CHF OF NAV RES ATTN HEAD PERS + TNG BR CODE 450
1 CHF OF NAV RES ATTN DIR PSYCHOL SCI DIV CODE 452
1 CHF OF NAV RES ATTN HEAD OF PSYCHOL BR CODE 452
1 OIC NAV PERS RES ACTIVE NAV YD WASHINGTON
4 LIB OFC OF NAV RES BR OFC 495 N KY
1 CHF OF NAV AIR TNG SCI DEPT NAV AIR STA PENSACOLA
1 CO NAV SCH OF AVN MED NAV AVN MED CTR PENSACOLA
1 CO MED FLD RES LAB CAMP LEJEUNE
1 COR NAV WPN CTR POINT MUGU CALIF ATTN TECH LIB CODE 3222
2 OIC NAV PERS RES ACTIVE SAN DIEGO
1 NAV AIR TECH TNG CTR MEMPHIS
1 NAV NEUROPSYCHIAT RES UNIT SAN DIEGO
2 COR NAV WPN CTR POINT MUGU CALIF ATTN HUMAN ENGNR DIV CODE N-555
1 OIC NAV PERS RES ACTIVE NAV STA NAV YD ANNEX WASHINGTON
1 NAV TNG PERS CTR NAV STA NAV YD ANNEX WASHINGTON ATTN CODE 83 LIB
1 CONTRL NAV BASE NORFOLK
1 COMDT MARINE CORPS HQ MARINE CORPS ATTN CODE AO-1B
1 HQ MARINE CORPS ATTN AX
1 DIR MARINE CORPS DIVE CTR MARINE CORPS SCH QUANTICO
ATTN SECRET + CONF FILES OP
1 DIR MARINE CORPS INST ATTN EVAL UNIT
1 CHF OF NAV OPNS OP-07T1
1 CHF OF NAV OPNS OP-551
1 CHF OF NAV OPNS OP-3772
1 CHF OF NAV AIR TRLN TNG NAV AIR STA MEMPHIS
2 COMDT 8TH COAST GUARD HQ
1 CHF OPNS PERS RES + REVIEW DR COAST GUARD HQ
1 OPNS ANLS OFC HQ STRATEGIC AIR CMD OFFUTT AFB
1 AIR TNG COMD RANDOLPH AFB ATTN ASPTR
1 DIR OF PERS PROGM + ATTENTION AIR FORCE MILIT PERS CTR RANDOLPH AFB
1 HQ AIR FORCE ATTN AFCIN-SD1
1 CHF SCI DIV DRCTR SCI + TECH DCS R+D HQ AIR FORCE ARNOLD
1 CHF SPEC WARFARE DIV DRCTR OF PLANS + OPNS DCS-PLANS+OPNS
HQ AIR FORCE
1 CHF OF PERS RES BR DRCTR OF CIVILIAN PERS DCS-PERS HQ AIR FORCE
1 CHF EVAL RELATIONSHIP CAREER DEVEL DIV DRCTR OF PERS PLAN HQ AIR FORCE
1 AIR FORCE STAFF COLL SCI + TECH LIAISON OFC (INTERNAT CO OR
1 CHF COMM STUDY GP SAFOSSO BOLLING AFB STOP 5-20
1 TEC ANN RPT REQ LIB HQ-AAT
2 HQ AIR FORCE STAFF COLL SCOB S ANDREWS AFB
1 AMRL AIR TRVEL DETN WASH UNIVERSAL AFB
2 COR ELEC SYS DIV L G HANSCOM FLD BEDFORD MASS ATTN ESD-TRI
1 LACKLAMENED AIR NAT AREA SMALL-PERS RES MCLELLAN AFB
1 1ST TNG COMD ATTN: M RANDOLPH AFB
1 AMRL RES LAB WRGHT-PATTERSON AFB
1 AIR MOVEMENT DESIGNATOR WRGHT-PATTERSON AFB
1 HQ MAC/TIS/SY SYS DIV PERS SURVYS BR SCOTT AFB
2 MILIT TNG CTR OPR LACKLAND AFB
1 ANTHN AERO MED RES LAB WRGHT-PATTERSON AFB
1 AIR MOVEMENT DESIGNATOR ARBN BRIDGES AFB
1 DCS-TECH TNG DIR MILIT + SPT TNG RANDOLPH AFB
4 HQ AIR TRANS COMD ATCIO-M RANDOLPH AFB
1 COR ELEC SYS DIV L G HANSCOM FLD ATTN ESTI
1 DIR STR U LIB MAXWELL AFB ATTN AUL/T-63-251
1 AIR FORCE SCH OF AEROSPACE MED BROOKS AFB ATTN AERORSCH LIB
1 DIR OF LIB US AIR FORCE ALAD
1 LONDON AFCTSL AEROMED LAB APO 731 SEATTLE
1 ANTHN AERO MED LAB FRA+ AEROSPACE MED DIV LACKLAND AFB
1 TECH TNG CTR INT LOWRY AFB
1 DIR NATL SECUR AGY FT GEO G MEADE ATTN DIR OF TNG
1 GENERAL INTEL AGY ATTN OLR MAIL RM
1 DEPT OF STATE BUR OF INTEL + RES EXTERNAL RES STAFF
1 SCI INFO EXCH WASHINGTON
1 CHF AERO TNG RM TNG DIV FED AVN AGY ATTN FT 38
1 CHF PERS RES STAFF OFC OF PERS DEPT OF AGRICUL
1 RES INFO CTR NATL BUR OF STANDARDS ATTN RES PSYCHOL
1 CHF PSYCHOL BR CIVIL AEROMED RES INST FED AVN AGY OKLAHOMA CITY
1 SYS DEVEL CORP SANTA MONICA ATTN LIB
2 DUNLAP + ASSOC INC DARIEN ATTN LIB
1 RES ANLS CORP BETHESDA
1 RAND CORP WASHINGTON ATTN LIB
1 U OF ILL GF EFFECTIVE RES LAB
2 U OF SO CALIF ELEC PERS RES GP
1 COLUMBIA U ELEC RES LABS ATTN TECH EDITOR
1 MITRE CORP BEDFORD MASS ATTN LIB
1 WESTERN ELECTRIC CO KINSTON-SALEM
2 U OF PUH LEARNING RAD CTR ATTN DIR
1 HUMAN SCI RES INC NORFOLK
1 WESTERN ELECTRIC CO INC NY
1 HUMAN ECOLOGY FUND WASHINGTON
1 HUMAN SCI RES INC MCLEAN VA
2 TELE INFO CTR ENGNR DATA SERV N AMER AVN INC COLUMBUS O
1 CHRYSLER CORP MSL DIV DETROIT ATTN TECH INFO CTR
1 SORO ANLS U ATTN LIBN
1 RAYTHEON CO ELEC SERV DUBS BURLINGTON MASS
2 EDLE + TAP CONSULTANTS LOS ANGELES ATTN PRINCIPAL SCI
1 INFO SYS DEPT LKT SPACE + INFO SYS DIV N AMER AVN INC DOWNEY CALIF
1 GEN DYNAMICS POMONA CALIF ATTN LIB
1 BELL AEROSYS CO CASTLE AFB
1 AVN CRASH INJURY RES SKY HARBOR AIRPORT PHOENIX ATTN TECH LIBN
2 RAND CORP POMONA CALIF ATTN DEPT 580
1 REFLECTONE ELEC INC STAMFORD CONN
1 CHF PERS SUBSYS BOEING AIRPLANE DIV MS 74-90 RENTON WASH
1 SYLVANIA ELECTRIC PRODUCTS INC NEEDHAM HGTS MASS ATTN PERS SUBSYS MANGR
1 THIOKOL CHEM CORP HUNTSVILLE DIV LOS ANGELES ATTN LIBN
2 SORO FLD OFC OFC OF SCCY SPEC WARFARE SCH FT BRAGG
1 DIR OF RELIABILITY + VALUE ENGNR BELL AEROSYS CO BUFFALO
1 INST FOR DEF ANLS RES + ENGNR SUPPORT DIV WASHINGTON
1 HUGHES AIRCRAFT COMPANY CULVER CITY CALIF
1 DIR LTR FOR RES ON LEARNING + TEACHING U OF MICH
1 OHIO STATE U
1 BOSTON TNG RES ABSTR AREA SOC OF TNG DIRS U OF TENN
1 U OF CHICAGO DEPT OF SOC
1 GEO WASHINGTON U DEPT OF PSYCHOL
1 HUMAN FACTORS SECT RAD GEN DYNAMICS ELECTRIC BOAT GROTON
1 DIR SORO ARMY U
6 BRITISH EMBSY BRITISH DEF RES STAFF WASHINGTON
3 CANADIAN JOINT STAFF OFC OF DEF RES MEMBER WASHINGTON
1 CANADIAN ARMY STAFF WASHINGTON ATTN LIOJ2 TRG
2 CANADIAN LIAISON OFCR ARMY AFROTC 60 FT KNOX
3 ACS FOR INTEL FOREIGN LIAISON OFCR TO NORWEG MILIT ATTACHE
2 ACS FOR INTEL FOREIGN LIAISON OFCR FOR SWEDISH EMBSY ATTN ARMY ATTACHE
1 NATL INST FOR ALCOHOL RES OASH
1 GERMAN LIAISON OFCR ARMY AVN TEST BD FT RUCKER
1 BELGIAN LIAISON OFCR ARMY AVN TEST BD FT RUCKER
1 AUSTRALIAN EMBSY OFC OF AIR ATTACHE WASHINGTON ATTN T A NAVSN SANN LIB
1 TOKA U DEPT OF PSYCHOL
2 AUSTRALIAN EMBSY OFC OF MILIT ATTACHE WASHINGTON
2 U OF SHEFFIELD DEPT OF PSYCHOL
1 MENNINGER FOUNDATION TOPEKA
2 AMER INST FOR RES WASHINGTON
1 AMER INST FOR RES PALN ATTN LIBN
1 COLUMBIA U SCH OF BUS
1 MITRE CORP ARLINGTON ATTN TECH LIBN
1 AMER TELETEL CO NY
1 U OF GEORGIA DEPT OF PSYCHOL
1 BERKELEY CALI DEPT OF PSYCHOL
1 GEN ELECTRIC CO SANTA BARBARA ATTN LIB
1 KITRO LABS SILVER SPRING MD ATTN LIBN
1 TENN VALLEY AUTHORITY KNOXVILLE ATTN LABOR RELATIONS OFCR DIV OF PERS
1 U OF GEORGIA DEPT OF PSYCHOL
1 U OF UTAH DEPT OF PSYCHOL
1 AMER INST FOR RES LOS ANGELES
1 AMER INST FOR RES PALO ALTO CALIF
1 MICH STATE U COLL OF BUS SCI
1 N DOS STATE U
1 GOULARD + CO HADDONFIELD NJ ATTN PRES
1 NORTHROP CORP ANAHEIM CALIF
1 LING TECHCO VOUGHT INC WARREN MICH ATTN HEAD HUMAN FACTORS
2 AIRCRAFT APPARENTS INC COCKEYSVILLE MD
1 AMER MACH + FOUNDRY CO GREENWICH ENGNR DIV STAMFORD CONN
2 OREGON STATE U DEPT OF MILIT SCI ATTN ADJ
1 TUFTS U HUMAN ENGNR INFO + ANLS PROJ
1 AMER PSYCHOL ASSOC WASHINGTON ATTN PSYCHOL ABSTR
1 NU ILL U HEAD DEPT OF PSYCHOL
1 GEORGIA INST OF TECH DIR SCH OF PSYCHOL
1 OHIO STATE U DEPT OF AVN
1 REPUBLIC AVN CORP FARMINGDALE LONG ISL ATTN SUPERV ENGNR LIB
1 WASHINGTON ENGNR SERV CO INC KENSINGTON MD
1 LITC SCI INC FT WORTH ATTN PRES
1 AMER RESRCH SCI NY
1 INTERNATL INVENTION CONSULTS CHICAGO
2 DIR INSTR RESOURCES STATE COLL ST CLOUD MINN
1 COLL OF WM + MARY SCH OF EDUC
1 SO ILLINOIS U DEPT OF PSYCHOL
2 COMMUNICABLE DISEASE CTR DEVEL + CONSULTATION SERV SECT ATLANTA
1 NORTHWESTERN U DEPT OF INDUST ENGNR
1 NY STATE EDUC DEPT ABSTRACT EDITOR AVLR
1 CMF PROCESSING DIV DUKE U LIB
1 U OF CALIF UCH LIB DOCU DEPT
1 FLORIDA STATE U LIB GIFTS + EXCH
1 HARVARD U PSYCHOL LABS LIB
1 U OF ILL LIB SER DEPT
2 U OF KANSAS LIB PERIODICAL DEPT
1 U OF NEBRASKA LIBS ACQ DEPT
1 OHIO STATE U LIBS GIFT + EXCH DIV
1 PENNA STATE U PATTEE LIB DOCU DESK
1 TULANE U LIBS PERIODICALS CHECKING FILES
1 STANFORD U LIBS DOCU LIB
1 LIBN U OF TEXAS
1 SYRACUSE U LIB SER DIV
1 U OF MINNESOTA LIB
1 STATE U OF IOWA LIBS SER ACQ
1 NO CAROLINA STATE COLL ON HILL LIB
2 BOSTON U LIBS ACQ DIV
1 U OF MICH LIBS SER DIV
1 BROWN U LIB
2 COLUMBIA U LIBS DOCU ACQ
1 DUK JOINT U LIBS NASHVILLE
1 U OF DENVER MARY REED LIB
2 DIR U LIB DOD WASHINGTON U
2 LIB OF CONGRESS CHF OF EXCH + GIFT DIV
1 U OF PUH DOCU LIBN
1 OFC OF DIR CATHOLIC U LIB ATTN PSYCHOL DEPT LIB
1 U OF KY MARGARET I KING LIB
1 SO ILL U ATTN LIBN SER DEPT
1 KANSAS STATE U FARRELL LIB
1 BRIGHAM YOUNG U LIB SER SECT
1 USAEORS REDSTONE ARSNL ATTN AJO
1 DRUM SCI RES LAB INC ARLINGTON
1 LIBRN DEPT OF PSYCH GEORGIA INST OF TECHNOLOGY ATLANTA
1 MILIT ASST SYS DIV BOEING CO SEATTLE
1 LO 24TH DIV (MECH) ORTT AVN SECT APO 29 NY
1 OFC OF THE SURG GEN HQ DA ATTN AVN SECT
1 ARMY TRANS RES CORD FT EUSTIS
1 CHF AVIONICS + NAVIGN AIDS CMDTS OFC ARMY ELEC CMD FT MONMOUTH
1 PLANS OFCR ARMY CMDC FT ORD
1 AVN OFCR ARMY CDEC FT ORD
1 DISPLAY SYS DEPT HUGHES ACFT CO CULVER CITY CALIF
1 CO WRIGHT-PATTERSON AFB
1 CORNELL AERONAUTICAL LAB BUFFALO
1 PETA OPTY FOR EFFECTIVENESS TEST (PSTT) EGLIN AFB
1 NAVAL ORD LAB SILVER SPRING
1 IBM-SPACE GUIDANCE CTR ONNEGO NY
1 AUTONETICS ANAHEIM CALIF ATTN TECH LIB
1 WRIGHT-PATTERSON AFB ATTN SEMCO
1 APL/JOHNS HOPKINS U SILVER SPRING
1 DIR ARN-AIR MOBILITY DEPT USAIS FT BENNING
1 DEPT OF PSYCH VANDERBILT U NASHVILLE
1 AVN MED ACCELERATION LAB NAVAL AIR DEVEL CTR JOHNSVILLE PA
1 HUGHES ACFT CO CULVER CITY CALIF ATTN LO TECH DOCU CTR
1 PERS + TNG BR PSYCHOL SCI DIV OFC OF NAV RES